MODIFICATION AND FURTHER DEMONSTRATION OF THE BLAKE FLOATING HATCHERY/NURSERY CULTURE SYSTEM

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Project Funding:

		% of Total
Requested	**19,745**	**46%**
Match (in-kind)	**22,941**	**54%**
Total	**42,686**	**100%**

Project Period:

April, 1999 - November, 1999

FINAL REPORT

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(Picture 1)

Introduction and Background

According to the Massachusetts White Paper and Strategic Plan (September 1995), "the Massachusetts shellfish aquaculture industry is presently limited by seed availability". According to survey information collected by the Massachusetts Department of Food and Agriculture in 1998, "there is (still) a persistent and growing demand for commercially valuable shellfish seed for growout in private cultivation and public resource enhancement operations". Presently, 50-70% of the shellfish seed cultured by Massachusetts growers is purchased out of state. The Massachusetts Division of Marine Fisheries (DMF) allows growers to purchase seed stock from certified hatcheries as far north as Maine and south to New Jersey. The importation of disease and questionable genetic fitness of the seed stocks from outside of this area are factors in the DMF's seed importation policy. As more growers enter the industry, the demand for dependable, disease free sources of seed shellfish will increase. To this end, the Department has issued RFR#AGR-AQUA299 to "address the shellfish seed shortage through implementation of strategies, demonstration of innovative technologies, research, development, and/or feasibility studies that provide near and long term options for increasing the availability of commercially valuable shellfish seed...".

Concerns about the importation of disease and the preservation of local genetic diversity make the development of local hatcheries the logical solution to the shortage of seed for growers. Effluent regulations and monitoring requirements, which greatly discourage large point source discharges into the marine environment, increase almost logarithmically with the size of the hatchery facility, and economically discourage large operations. The ideal hatchery, then, becomes one that is not only local but also small.

In most of coastal Massachusetts, however, finding a waterfront site suitable for a hatchery, large or small, is nearly impossible. The state's large coastal population and massive coastal tourist industry create intense demands for waterfront real estate. Desirable waterfront sites for hatchery operations are either astronomically priced or zoned residential.

Jack Blake, a commercial fisherman and graduate of the Martha's Vineyard Aquaculture Training Program, designed and constructed a prototype floating hatchery/nursery shellfish culture system to supply quahog seed for Sweet Neck Farm, his new aquaculture business. Combining shellfish hatchery and on- and off- shore nursery culture methods which he learned in the MVSG Aquaculture Training Program with his extraordinary

talent for invention, Mr. Blake designed a low cost floating shellfish culture system with the capacity to produce one million 1 mm seed shellfish from fertilized eggs. The floating culture system incorporates battery powered seawater and air delivery systems, water filtration capabilities, a larval culture tank, post-set downweller culture units, and juvenile upweller silos.

The culture system holds promise to provide a low cost and environmentally sound means of producing the shellfish seed required by the developing shellfish aquaculture industry. The floating design of the system eliminates the high real estate costs inherent in a land based system. The small size of the system limits the volume of the point discharge so as to have negligible impact on the marine environment. Consequently, permitting costs associated with the system are minimal. The system is compact and is designed to be operated by one or two culturists. The system is visually and acoustically benign which should allow for its deployment in developed coastal areas. Further, this inexpensive small culture system can potentially provide for the local production of seed shellfish from indigenous stocks, thereby lessening chances of the importation of disease and allowing for the production of seed genetically fit to the local environment.

Under a 1998 grant from the Massachusetts Department of Food and Agriculture, Jack Blake constructed and operated the floating hatchery/nursery prototype. The floating hatchery/nursery successfully operated in three culture modes -- as a 340 gallon larval tank, as a nursery capable of handling eight downweller sieves for post set culture, and as a nursery with eight upweller silos for rearing juveniles. The first two attempts at larval culture of quahogs failed. During the first attempt, fertilized eggs introduced to the flow through larval culture system escaped when a drain screen dislodged. A second attempt was made to culture quahog larvae. This time the larvae were cultured in a closed system tank where water was changed every other day, and cultured phytoplankton was fed daily. This culture succumbed to a *Vibrio* infection traced to source water which was drawn from a prefilter reservoir contaminated with oyster feces from an adjacent nursery culture system. In a third attempt, two million two week old oyster larvae introduced into the system were successfully grown in a closed system mode. Within a week, the larval veligers progressed to eyed larvae and were set on microcultch in the system's downweller sieves. Juvenile oysters were eventually cultured in upweller silos in the prototype. This culture attempt resulted in over 110,000 (5-20 mm) oyster seed. The results for the 1998 trials were promising and led to the submission of the proposal under which the work in this report was funded.

We proposed to operate Mr. Blake's innovative shellfish culture system for another season to demonstrate its full potential. During the operation of the prototype in 1998, we identified and corrected a number of mechanical and biological problems. Building upon experience gained during the 1998 culture trials, we proposed to modify the culture system and repeat the culture trials with the improvements we made to the system. To reduce the need to exchange the batteries as frequently and to improve the efficiency of the operation, the proposed modifications included fitting the prototype's electrical system

with a wind generator designed to provide 500 watts per day at optimal conditions of 30 mph winds.

Project Participants

The legal applicant for the project was the Martha's Vineyard Shellfish Group Inc., a 501(c)(3) non-profit consortium of the shellfish departments of the towns on Martha's Vineyard. Rick Karney, the Shellfish Biologist/Director of the MVSG, administrated and provided the biological expertise in the investigation. Jack Blake, a commercial fisherman turned aquaculturist, designed, constructed and operated the prototype floating hatchery/nursery. Lori Karney, Sean Grealey, and Patrick Stewart, Hatchery Assistants with the MVSG, assisted in the project.

Statement of Work

List of Tasks:
a. Administration and bookkeeping
b. Purchase equipment
c. Monitor environmental parameters of site and shellfish growth
d. Maintain back-up algal cultures
e. Launch and systems shakedown
f. Operate and maintain culture systems
g. Collect and spawn broodstock
h. Culture larvae
i. Culture post-set on downwellers
j. Culture juveniles in upwellers
k. Transfer seed to nursery trays
l. Haul, drain and scrape down system
m. Evaluate data and prepare reports

Tasks Completed:

a. Administration and bookkeeping -- Following the award of the contract in early April, Karney met with Blake and Diane Leonard, the bookkeeper, to coordinate the project's schedule and financial management. As the award of the contract came so close to the end of FY99 and most of the work was scheduled to occur after the end of FY99, a dedicated account was set up for the funds at the Martha's Vineyard Cooperative Bank under the name "Martha's Vineyard Shellfish Group, Blake Hatchery II" with the account #20867850.

The lack of affordable housing on the Vineyard resulted in the resignations of several of the assistants early in the project. Eventually a stable assistant staff was in place. Karney in his capacity as MVSG Director signed off on all expenditures for labor and equipment. Diane Leonard issued checks, kept the books and prepared financial reports. In addition to this final report, interim progress reports were submitted on 3. May and 30. June, 1999.

b. Purchase equipment -- Shortly after the award of the contract, Mr. Blake located and ordered an "Air Marine 304" 400 watt air turbine for the floating hatchery. As a 500 watt generator rated for marine use (originally proposed) could not be found, the 400 watt model was purchased. Purchases of an amp meter, fuse and fuse holder completed the acquisition of the wind generator system. A replacement Rule pump and replacement storage batteries were the only other equipment purchases for the project. A $300 premium for a general liability insurance policy for the structure was part of the proposal and was paid.

c. Monitor environmental parameters of site and shellfish growth -- On eight occasions between 23. July and 12. October, environmental parameters expected to influence the growth and survival of cultured shellfish were measured. Using an Horiba Multiprobe and YSI Dissolved Oxygen Meter, measurements were taken for dissolved oxygen, pH, conductivity, turbidity, water temperature, and salinity. In conjunction with these measurements, Secchi disk measurements were taken to provide some indication of relative available phytoplankton food densities. The data are summarized in the table attached in section m. Evaluate data and prepare reports. Shellfish larvae and seed were sized with sieves throughout the project. Seed quahog growth was measured as an increase in volume. The total production of oyster seed from the floating hatchery was counted and measured on 12. October and appears in a tabulation in section m.

(Pictures 2 & 3)

d. Maintain back-up algal cultures -- Various cultures of phytoplankton were maintained in the MVSG hatchery throughout the project period. Plans were to add the algae if the flow through system failed to supply adequate natural phytoplankton for good nutrition of the developing shellfish larvae. When it became necessary to grow the larvae in a static system, these cultured algae were provided as food for the shellfish larvae . The stock cultures included Tahitian strains of *Isochrisis*, three *Tetraselmis* species, two *Chaetoceros* species, and the diatom *Thalassiosira weissfloggi*. The larvae cultured in the floating hatchery system were fed with cultures of *Isochrisis galbana* (Tahitian strain, T-Iso), *Chaetoceros neogracili* (Chaet B) and *Tetraselmis chuii*(T. chuii).

e. Launch and systems shakedown -- Although the generator was ordered soon after the award of the contract, a backorder from the factory delayed delivery and installation of the generator and subsequently, delayed the launch of the hatchery from a scheduled date in early June until early July. Upon delivery in late June, the generator was installed. The hatchery system was cleaned and launched on 5. July. It was towed to the mooring site in "the narrows" of Katama Bay and bolted to Blake's tidal upweller nursery which was already on the mooring.

(Picture 4)

A shakedown of the mechanical systems began on 5. July. To test the system, two prefilter bags (800 micron and 300 micron) and two 5 micron, tall(31") filter bags were installed. A pump set to deliver 4,000 gallons per day and the wind turbine were turned on. On 7. July, the batteries were observed to be charged at 100% after pumping 16 hours. The wind had been blowing 10-15 mph during the day with no wind at night. On 9. July, the two 5 micron bags and the prefilter bags were changed and cleaned and three new 51 micron exit sieves were installed in the larval tank. The batteries were observed to still have a full charge. On 10. July, the bags were again changed, the exit sieves rinsed and the pumps set to pump 9,000 gallons per day. The systems were tested until 12. July at which time the systems were cleaned in anticipation of the start of the first culture trial.

f. Operate and maintain culture systems -- The floating hatchery/nursery is capable of operating in three culture modes -- as a 340 gallon larval tank, as a nursery capable of handling eight 18" diameter by 7" deep downwellers for post-set culture, and as a nursery with eight 18" diameter by 14 1/2" deep upweller silos for rearing juveniles.

Ambient seawater enters the system through an opening in the bottom of the raft platform that is 3" by 12", and is three feet up current from the discharge pipe. The water passes through a series of bags in prefilter raceways recessed in the floor of the platform. Nytex screen bags with 300 and 800 micron mesh are fitted into the intake raceway to prefilter all seawater entering a sink. From this prefilter box, the coarse filtered water flowed to the sink via a 2" PVC pipe controlled with a gate valve. The gate valve at the bottom of the sink allows for the control of how much water passes through the system on a daily basis.

When the water level in the recessed sink is about 2" below sea level (nearly full), a float switch turns on a submersible pump in the bottom of the sink and pushes the water up 5.5 feet so as to spill into filter bags hanging over an 18 gallon open holding tank. Water passes through filter bags of 5 to 50 microns (depending upon the size of the animals being fed) and into the holding tank. An overflow pipe from the holding tank allows the filtered water to spill into the larval tank. A 2" ball valve on this line may be shut when changing the bag filters, in order to prevent contamination of the larval tank. The filtered water flows into a manifold with eight outlets each of which has 2-3' of vinyl hose attached. The filtered water dropping from these hoses provides aeration and water movement within the larval tank. Water exits the larval tank through three exit sieves of 51 micron mesh. The effective filter area of the exit sieves is about 700 square inches.

In the original design, the standpipe was connected to the sink with a 1 1/2" flexible hose. This drain hose passed through the sink and connected to a 1 1/2" ball valve located downstream from a 1" barb fitted with 1' of vinyl hose with a spigot at the end. In flow through operating mode, the drain ball valve in the sink is opened and water discharges through a bulkhead fitting 2" below sea level. To drain the larval tank and contain the larvae, the valve is shut, the spigot opened, and the larvae caught on an appropriately sized sieve.

In the course of the operation of the floating shellfish hatchery/nursery prototype, Jack Blake corrected flaws in his culture systems. Changes were made in both pre-filters and drain filters. The larval tank standpipe was redesigned to allow the use of a siphon hose rather than the bottom hose for draining the larval tank. Modifications were made to better secure siphon hoses and drain sieves to accommodate the instability of an open water hatchery system. The addition of a 400 watt air turbine to the system prior to the 1999 trials reduced the frequency with which the batteries had to be changed.

(Pictures 5 & 6)

Throughout the culture period, the system was checked daily. Intake screens were cleared, filter bags cleaned, and batteries exchanged and recharged as necessary. In static water larval cultures, the larval tank was drained, cleaned, and refilled every other day. At these times, the larvae were sieved, examined, and culled.

(Picture 7)

g. Collect and spawn broodstock -- Mr. Blake collected quahog broodstock for the first spawning from Caleb's Pond in Edgartown on 11. July. The broodstock were brushed in fresh water and left at room temperature overnight in preparation for the spawning at the MVSG Hatchery on 12. July. The quahogs were distributed in Pyrex dishes filled with 5 micron filtered seawater and subjected to thermal stimuli to induce spawning. Over the course of five hours, seven females and six males produced over 20 million fertilized eggs.

Following the failure of the first culture trial, attempts were made to spawn quahogs again on 20. and 21. July. These spawning attempts failed to produce sufficient numbers of eggs to carry out another culture trial. We suspect that the broodstock used were already spent.

The second larval culture trial utilized surplus oyster larvae from an oyster spawning conducted at the MVSG Hatchery on 23. July. In this spawning, 15 females and 5 males produced over 239 million fertilized eggs!

h. Culture larvae --
First Trial
The first culture trial was an attempt to culture quahog larvae in a flow-through larval system. Our one 1998 attempt at flow-through water larval culture identified the larval tank exit sieves as the obstacle to our success. In 1998 the removable nylon mesh bag sieves could not be reliably secured and were found to loosen and fall off under the repeated sloshing of the floating hatchery from the wakes of passing boat traffic. In an attempt to remedy the problem, three new exit sieves were crafted from slotted 6" x 18" PVC pipe to which 51 micron mesh was glued. The filters were threaded so that they could be securely fastened to both the center standpipe and side wall of the larval tank. The new exit sieves increased the surface area (700 sq. ") seven times over the mesh sieves that were used in the 1998 design. The greater surface area translated into less

chance of clogging and a greater insurance that the larval tank would not overflow and lose larvae. The exit sieves were tested and performed well during the mechanical systems shakedown in July.

On 12. July prior to adding the quahog embryos, Blake power washed the prefilter reservoir, sink, holding tank and larval tank to lessen the chance of bacterial contamination. The filter bags and batteries were changed. The exit sieves of the larval tank were cleaned. The tank was filled with water filtered to 5 micron. To set the water flow at a constant 4,500 gal/day, all control valves were opened and a restricting plug with a 19/32" hole was inserted into the entrance line. This eliminated the need to readjust the valves. Once all the systems were set, 20 million embryos spawned in the MVSG hatchery earlier in the day were transferred in seawater in Nalgene carboys to the site and introduced into the larval tank of the floating hatchery. The tank received a flow of approximately 146/gal per hr. of 5 micron filtered seawater.

(Picture 8)

On the next day, 13. July, the hatchery was checked. The exit sieves were only partially clogged but were removed and cleaned. The batteries were fully charged. The wind was blowing at 25mph and the wind turbine was observed to turn off 15 seconds after the pump turned off and would come on again as soon as the pump switched on. The prefilter bags and the 5 micron bag filters were less than half clogged so they were not touched.

(Picture 9)

On 14. July, the exit sieves and prefilter bags were rinsed clean. The bag filters were replaced with clean dry bags. The batteries still carried an adequate 85% charge. To the naked eye, swimming larvae appeared to fill the tank.

On 15. July, the filter bags were replaced, the exit sieves were cleaned and the batteries checked out at 60%. A water sample from the surface of the tank and one from the exit sieves were collected for microscopic examination. No quahog larvae were found in the surface sample. The exit sieve sample revealed lots of copepods and only a few quahog larvae. The larvae were observed to be hollow looking and in poor health. We speculated that the poor condition of the larvae was due to either a lack of food due to competition from the copepods or stress resulting from impingement on the mesh of the exit sieves. We were puzzled by the high numbers of copepods in the culture as all water being pumped into the system passed through 5 micron filter bags. We concluded that the only way the copepods could be entering the system was through the 51 micron mesh of the exit sieves. When a wave or boat wake hit the exit bulkhead fitting there was a positive pressure flow back into the tank. Though only for a second or two, with lots of boat traffic this could provide a significant route of entry for the copepods. This problem could probably be solved by raising the exit port but would require a major redesign of the flotation and plumbing. Blake suggested that a check valve in the exit port might help.

The flow-through larval culture was continued for two more days. A sample examined under the microscope on 17. July showed more copepods than quahog larvae and it was decided to abort the culture and spawn again.

Two all day attempts to spawn different groups of broodstock quahogs on 20 and 21. July failed to provide enough eggs for a culture trial. We suspected that the quahogs had already spawned out.

Second Trial

The second larval culture trial was conducted as a closed system aerated culture with additions of cultured phytoplankton food and a drain down and change of seawater every second day. The air compressor used more amperage than the water pump and, despite the air turbine, required an exchange of the batteries about every two days.

On 25. July, 10 million 48 hour old oyster larvae from the first drain down of the MVSG hatchery culture were introduced to the larval tank of the floating hatchery. On 26. July four liters of cultured phytoplankton (2L *Isochrisis galbana*[T-ISO]; 2L *Chaetoceros neogracili.*[Chaet B]) were added to the aerated larval tank.

On 27. July the contents of the tank was siphoned down into a 51 micron sieve. The larvae were concentrated in a bucket and mixed well before a 1 ml sample was taken for microscopic examination and counting. The larvae were sieved and about 1/3 were retained on a 85 micron sieve. The tank was sponged clean, refilled with 5 micron filtered water and the larvae were restocked into the tank. Six liters of algae (2L Chaet B and 4L *Tetraselmis chuii*[T.chuii]) were added. The batteries were changed.

(Pictures 10, 11, 12, 13 & 14)

Upon observation of the larval samples under the microscope, 80% appeared to be in good health and the count was estimated at over 5.5 million. It should be noted that the samples transferred in vials from the field to the counting cells of the microscope did not provide a truly accurate count of the larvae, and should only be considered estimates. Some of the larvae remained attached to the walls of the vials, so that our counts were always less than what was actually in the tank.

The field notes of 29. July reported that the water in the tank was clear, indicating healthy and feeding larvae. Nine liters of algae (3L T-ISO and 6L T.chuii) were added.

On 29. July, the tank was drained. The larvae were sized on sieves with about two thirds of the volume catching on a 103 micron sieve. All of the 103 micron larvae and about half of the larvae caught on an 85 micron sieve were returned to new seawater in the tank. The culture was fed with 9 liters of algae (3L T-ISO and 6 L T.chuii). On 30. July, 12 liters of algae (4L Chaet B and 8 L T.chuii) were added.

Following the drain down on 31. July, most of the volume of the larvae was retained on a 130 micron sieve; the rest on a 103 micron. A few of the larvae observed under the microscope appeared to be developing eye spots. The count was estimated to be about 3 million. All larvae were resuspended in the tank and fed about 12 liters of algae (8L T. chuii and 4L Chaet B). On 1. August the larvae were fed another 12 liters of the same algal mix.

By the 2. August draindown, half the volume of larvae sat on a 150 micron sieve with the rest equally distributed on 130 micron and 103 micron sieves. The count was two million and more eyed larval were found. All the larvae was replaced in fresh seawater in the tank and fed 9 liters of algae (4L T-iso and 5L chuii). They were fed again on 3. August with 11 liters (4L T-iso and 7L chuii)

Following the draindown on 4. August almost all the larvae stayed on 150 and 130 micron sieves. The small amount still on the 103 micron sieve was released. The count was still estimated to be 2 million. The larvae were restocked and fed 11 liters of algal food (2L T-iso and 9L T.chuii). On 5. August they were fed 15 liters (5L T-iso and 10 T.chuii).

On 6. August most of the larvae were retained on 175 and 150 micron sieves. Smaller larvae were discarded. The count was estimated at 1.6 million. The larvae were fed 18 liters of algae (8 T-iso and 10L T.chuii). On 7. August they received an identical food ration. Due to poor weather conditions on 8. August, we skipped the scheduled draindown but fed 18 liters of the same food fed on 7. August.

On 9. August the tank was drained. Half of the larval biomass was caught on a 209 micron sieve with most of the rest on 175 micron. When the larvae were concentrated in the bucket, they displayed the clumping strand behavior typical of larvae near metamorphosis. The microscopic sample showed 75% to be eyed. In preparation for setting, the larvae were concentrated on nylon mesh which was wrapped in paper towel soaked in seawater, and refrigerated overnight.

i. Culture post-set in downwellers -- Downweller sieves and cultch were made ready for setting the eyed oyster larvae. The interior side surfaces of 8 downweller sieves were coated with paraffin wax to discourage setting and make removal of any set oysters easier. Two kinds of calcium rich substrates were used as setting cultch -- crushed oyster shell and sterilized crushed poultry shell. Both materials were purchased in pet stores where they are sold as calcium supplements for caged birds. Both the egg shell and oyster shell were graded using 400, 560, 740 and 1,000 micron sieves. One downweller had 400 micron egg shell; one had 560 micron oyster shell; one had both egg and oyster shell that sat on the 560 micron sieve. The remaining five had mostly large chip oyster shell that caught on 740 and 1,000 micron sieves. All downwellers had enough chip to cover the bottom of the downweller about two layers deep. In Blake's field notes from September he reported that the smallest shell, both oyster and egg, appeared to catch the most oysters.

(Picture 15)

The downweller sieves were set in the larval tank suspended from the central support structure which was attached to the standpipe. The 1.6 million eyed oyster larvae were distributed equally into the eight downwellers. The pump was set for a cycle of 7 minutes on and 3 minutes off or 350gal per/hr or 4,000 gal/day. Two 5 micron bag filters were put into place and expected to handle the flow. The batteries were changed with the expectation that they could run the pumps for four days with no wind. About 24 liters of algal food was added to the tank, the pump was turned on and the tank covered with a protective plastic tarp.

The hatchery was checked on 11. August. The two five micron bag filters were found to be completely filled and replaced. The batteries were fine. The oysters were still swimming.

On 12. August three clean 5 micron bag filters were put in place and it was hoped that they could handle the flow which was now about 12,000 gal per day. The prefilter bags were rinsed and the batteries tested OK. The field notes read that the wind had been blowing at 10-15 mph from about noon until sunset. On 13. and 14. August the bags were changed, the batteries checked and most of the larvae were still reported swimming.

By 15. August many oysters could be seen set on the egg shell and a membranous material that was part of the egg shell cultch. The bags were changed. The wind turbine was producing 3-5 amps so the batteries were fine. By 17. August a fourth bag filter was added and no more oysters were reported swimming. The set oysters were kept in the downweller mode for five more days.

j. Culture juveniles in upwellers -- The larval tank was modified and rigged to function in upweller mode. Blake drilled a 4 1/2" hole in the side of the tank for a 3" bulkhead fitting which provided a second intake port. The tank was lowered 7 1/2" and two 1500 gph pumps were installed inside of the standpipe. When in operation, the pumps created negative pressure which created a flow through the holes in the side of the tank with the water flowing through the upwellers and down the central standpipe. Eight upweller silos could be rigged in the tank.

(Pictures 16 & 17)

All the oyster cultch from the downwellers was sieved and put into three 600 and three 400 micron mesh upwellers. The seed that was still too small to stay on the 400 micron mesh was transferred to a 210 micron bin with a 310 micron cover and put in an adjacent tidal upweller nursery. A seventh upweller (600 micron mesh) was filled with 22,000 six mm quahog seed to investigate the growth of quahog seed in the system. Newly charged batteries were installed. With the seven upweller silos in place, one of the two pumps was turned on. One pump provided each upweller with 214 gph or 5,000 gallons per day.

Unfortunately the flow was found to be strong enough that all of the light membranous pieces of egg shell with attached oysters were floated out the exit.

On the next day the second pump was turned on increasing the flow to 70,000 gal per day through the seven upwellers. On 25. August everything in the system was cleaned. The oysters appeared to be growing. On 27. August the small seed oysters that had been moved to the bin in the tidal upweller had grown large enough to be moved back into a 400 micron mesh upweller. With both pumps on, the batteries were observed not to last for two days without wind. Over the course of the juvenile upweller culture, the batteries were changed almost daily and the upwellers were rinsed about every three days.

(Pictures 18 & 19)

On 5. September all the upwellers were sieved and some oysters were caught on 1680 micron mesh and were transferred to the tidal upweller. The oysters grew fast enough that they were required to be sieved about every nine days.

On 6. September quahog seed in the hatchery upweller was measured and found to be growing a little faster than an equal amount in a bin in the adjacent tidal upweller.

On 14. September the hatchery was checked and found to be full of ctenophores. They were clogging the bottom of the upwellers, making them float which caused the pumps to suck air and accumulate in a bubble under the tank lifting everything up about two inches so that little water could enter the standpipe. The jellyfish were vacuumed out of the tank with a 3800 gph pump but more jellyfish were entering the system. Blake suggested a requirement for large strainers on the two intakes.

On 15. September the hatchery was moved to a new mooring in Caleb's Pond as the site offered protection from the expected arrival of Hurricane Floyd. On 17. September the wind blew 40 mph with gusts to 60 mph. Despite the fact that there were no jellyfish in Caleb's, the hatchery floated differently when not attached to the tidal upweller and the pumps began to suck air which tended to raise the tank. The addition of about 300 lbs of ballast and cinder blocks brought the system to a proper level of flotation. The hatchery remained in Caleb's Pond for the rest of the season until it was hauled on 27. October.

k. Transfer seed to nursery trays -- Some of the oyster seed sieved on 5. September caught on a 1680 micron sieve and was transferred to two 1000 micron bins and one 1410 micron bin in the tidal upweller. This first seed to be moved to the tidal upweller grew to 12 mm by 1. October. The seed from the upwellers was sieved again on 18. September, 23. September, 29. September and 5. October. Each time the larger seed was moved to bins in the tidal upweller. A substantial amount of seed that had not grown large enough to be caught on a 1160 micron sieve by 5. October was discarded in the pond.

Biofouling of the oyster seed with hydroids became a problem for seed held in the tidal upweller. On 3. October three bins of the largest seed (about 12 mm) were brine dipped

for one minute and left to air dry for about two hours. This treatment was effective and on 9. October the remainder of the oyster seed was brined. On 11. October the seed was pressure washed to remove the dying biofouling. Blake believes he experienced some losses(2-5%) following the pressure washing. On 12. October all the oyster seed produced from the second trial in the floating hatchery was counted and measured. The results are tabulated in section m. Evaluate data and prepare reports below.

(Pictures 20, 21, 22, 23, 24)

l. Haul, drain and scrape down system -- On 5. October all seed was removed from the hatchery and transferred to the tidal upweller. Pumps were turned off and upwellers, standpipes and pumps were taken home to clean and store. On 27. October, the hatchery was towed to the landing, scraped of biofouling, and trailered to an onshore storage site where it was further cleaned. On 28. October, the wind turbine and batteries were removed from the unit. The batteries were set on a trickle charge for the winter.

m. Evaluate data and prepare reports

Environmental Data

Date	Water Temp (C)	D.O. (% saturation)	Salinity (ppt)	Conductivity (mili-siemens)	Ph	Turbidity (ntu's)	Secchi Disk (meters)
7/23/99	24.3	89.5	31.9	48.8	7.79	4	2
7/29/99	25.4	85.1	31.7	48.4	7.85	6.2	1.75
8/4/99	25.2	93.3	32.1	49.1	7.82	6	1.5
8/20/99	23.3	94	32	49.1	7.87	2	2
8/25/99	23.6	104.7	31.4	47.9	7.85	3	2.3
9/2/99	21.8	98	31.7	48.4	7.9	1	2.6
9/29/99	20	107	32.6	49.9	8.07	2.5	>2
10/12/99	15.9	81.8	33	50.1	7.98	1	5

Oyster Seed Produced in the Second Culture Trial of 1999

Amount	Size in mm
7,300	10
29,480	7
19,360	5
8,200	4
25,740	3
41,320	2
1,000	1.5-2
132,400	

Problems Encountered

The delay in the delivery of the air turbine from the distributor due to a back order from the factory, pushed back the launch of the floating hatchery from a scheduled date in early June until early July. Our plan to introduce 0.75 mm quahog seed into the prototype in early June to test the effectiveness of the prototype operating in the upweller culture mode during the month of June was scrapped. Blake did, however, conduct a more limited investigation comparing the growth of quahog seed in the hatchery upweller sieves vs. the tidal upweller bins between 22. August and 23. September.

On 22. August, 22,000 6 mm quahog seed with a volume of 2 liters was placed on one 600 micron upweller sieve in the floating hatchery. At the same time, an equal volume (2 liters) of the same quahog seed was put into each of two bins in the tidal upweller. About one month later the growth of the quahog seed in the two systems was compared. The seed in the two tidal upweller bins averaged a final volume of about 3 liters each. The seed ranged between 5-12 mm. On 23. September the quahog seed in the upweller in the floating hatchery was sieved through a 5 mm screen. About 2 liters were caught on the 5 mm mesh with the remainder, about 1.5 liters, falling through and catching on a smaller sieve. The increase of 1.5 liters in volume in the hatchery upweller compared favorably with an increase of only 1 liter in volume in the tidal upweller. The seed in the floating hatchery had been rinsed almost daily. The tidal upweller bins were rinsed weekly.

As in the 1998 trials, we again failed in our attempts to operate the unit in a flow-through larval culture mode. Our experiments, however, helped us to better identify the obstacles to our success and provided information helpful to the redesign of the system. As explained in the Statement of Work, preventing the influx of copepods through the exit ports will require major design changes which could not be attempted during the short temperature window of the culture season. The impingement of the larvae on the exit sieves, likewise, presents a major problem with no easy solutions coming to mind.

Time, tide and the spawning of quahogs wait for no man. Again in 1999, we had a small window of opportunity to conduct the quahog culture trials before the quahog broodstock, collected from the natural environment, were no longer ripe. We did not have available to us a chiller unit which would allow ripe broodstock to be held longer into the summer season and increase the opportunities for successful quahog spawnings.

Goals and Objectives

As we proposed, the project provided further demonstration of the Blake Hatchery's potential to provide a cost effective and environmentally friendly means of meeting the shellfish seed needs of shellfish growers. The 1998 trials successfully tested the prototype in all culture modes. All except the flow-through larval culture mode proved successful. Building on 1998's success, oyster larvae in 1999 were successfully taken through an essentially full larval cycle in the closed larval culture mode. The eyed larvae were then successfully set in the prototype's downwellers and finally grown out with success in the upweller silos of the floating hatchery/nursery system.

Although we fell short of our goal of producing one million 1 mm quahog seed, we did produce over 130,000 oyster seed. Survival of oysters from eyed to set juveniles in land based hatcheries is almost always less successful than quahogs due to complications associated with the addition of cultch material. This problem was compounded in the floating hatchery where the constant movement of the structure kept jostling the cultch impeding oyster attachment, and increasing the chances for abrasion and smothering. We have little doubt that had we been setting an equal number of quahog larvae rather than oysters in the downwellers, survival rates would have been higher and our production would have been near our proposed goal of one million.

The addition and demonstration of the wind generator to the prototype proved highly effective in increasing the efficiency of the culture operations. The labor intensive task of recharging and exchanging batteries was reduced considerably following the installation of the wind turbine.

Implementation of Results by the Massachusetts Aquaculture Industry

Although the unit is still far from being ready to be duplicated and distributed to local growers, the operation and demonstration of the prototype has answered questions and tested technologies that will very likely be a part of shellfish culture operations in Massachusetts in the not too distant future.

The innovative use of crushed poultry shell as oyster cultch in this investigation may have more immediate application for hatchery producers of oyster seed.

The concept has generated much enthusiasm in the Massachusetts aquaculture community and beyond. Karney has been asked to present results of the investigations at the Long Island Fishermen's Forum and will be giving presentations about the project at the World Aquaculture Society meeting in New Orleans and the annual NMFS Milford Aquaculture Seminar in Connecticut.

Economic Impact

It is still too premature to assess the economic implications of the Blake Floating Hatchery/Nursery system. The cutting edge technologies developed and tested in the project do, however, have great potential for the aquaculture industry. The economic potential of a shellfish hatchery culture system that promises to eliminate the need for costly waterfront real estate, especially in the Northeast, is significant. Although production data from the hatchery are still too few to realistically develop any kind of cost per unit analysis for the system, it is clear that in a capital outlay equation the Blake Hatchery's near zero real estate costs would compare favorably with the million dollar startup costs for real estate associated with a land based hatchery.

Environmental Benefits

The Blake Hatchery promises to eliminate disease and biodiversity concerns associated with importing seed stocks outside the local area.. The floating hatchery provides for the

local production of seed shellfish from indigenous stocks, thereby, lessening chances of the importation of disease and allowing for the production of seed genetically fit to the local environment. The system is visually and acoustically benign which should allow for its deployment in developed coastal areas. The small size of the system limits the volume of the point discharge so as to have negligible impact on the marine environment.

Dissemination, Outreach/Education and Technology Transfer

Efforts have been made to disseminate the information gleaned from the project. A local newspaper article about the project appeared in the Vineyard Gazette on 3. August 1999 (attached). Boston Channel 7, aired a small segment about the project as part of news coverage of President Clinton's Vineyard vacation in August. Karney is scheduled to present a paper entitled "Design of a Floating Hatchery and Performance Data for a Modified Tidal Upweller Nursery" at the Long Island Fishermen's Forum in January; at the World Aquaculture Society's Aquaculture America 2000 in New Orleans in February; and at the 20th National Marine Fisheries Service Milford Aquaculture Seminar to be held 28. February through 1. March in New Haven, Connecticut. This report will be available on a MVSG website presently under construction.

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Floating Hatchery/Nursery Captions for Pictures

1. The Massachusetts Department of Food and Agriculture supported the development and demonstration of the Blake Floating Hatchery/Nursery Culture System.

2. Jack Blake and assistant Patrick Stewart used the Horiba Multiprobe to monitor environmental parameters.

3. Secchi disk measurements were taken to provide a measurement of available phytoplankton food.

4. The floating hatchery was attached to Mr. Blake's Tidal Upweller in Katama Bay.

5. PVC pipe was used to stabilize the siphon hose and catch sieve during the drain down.

6. A new Air Marine 304 wind turbine was added to the hatchery in 1999.

7. Spawnings were conducted at the MVSG solar assisted hatchery.

8. Jack Blake power washing the prefilter reservoir.

9. Jack Blake rinses the larval tank exit sieves.

10. & 11. The larval tank was drained down using vinyl hosing.

12. When exposed to bright sunlight, the oyster larvae settled to the bottom of the larval tank, and appeared as clumped brown sediment.

13. During a drain down the larval tank was siphoned through a catch sieve in the recessed sink.

14. The larval tank was sponged clean after each drain down.

15. Egg shells sold as a calcium supplement for birds proved an effective oyster setting cultch.

16. Seven upweller silos in the floating hatchery tank. Rope was used to secure the silos to the central outflow pipe.

17. Another view of the upweller silos. Two intake ports are visible in side wall of the larval tank.

18. & 19. Oysters grew quickly in the upweller silos.

20. - 24. Various views of the largest oyster seed produced in the floating hatchery in 1999. The seed is about four months from spawning.

Jack Blake Takes to Farming in Katama Bay

By MARK ALAN LOVEWELL

Vineyarders love to eat seafood, and among their favorite bivalves is the oyster Consumers will pay top dollar for a fresh oyster, and the Vineyard is producing more for the summer market this year than ever before

Jack Blake of Edgartown, 45, is raising oysters using the latest in equipment and technology Only a few of his oysters are trickling into the market, but he hopes that by next summer, the Island's cultured oysters will have a high profile

With the help of the Martha's Vineyard Shellfish Group and grants from the government and a foundation, Mr Blake and four other shellfishermen are learning how to raise shellfish efficiently and profitably

Some of the technology being used comes from the shellfish group, and Mr Blake has invented some of his own techniques It has been a long process, until a few years ago, aquaculture on Martha's Vineyard seemed only a fisherman's dream

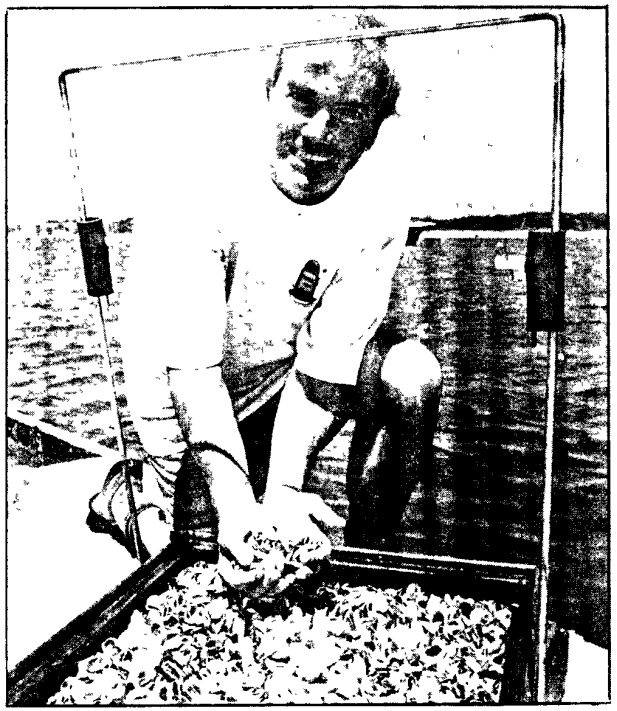
In the last two years, cultured oysters from Mr Blake and others have been served at a number of places on the Island, the result of experimental successes They've shown up at the Taste of the Vineyard and at a few private functions as well

Out in Katama Bay, Mr Blake operates two floating barges, one attached to the other One boat is a small floating shellfish hatchery with 3 million microscopic oysters in a tank

In front of it is a plywood floating raft that serves as a tidal-powered shellfish nursery The currents that naturally flow through the bay send a powerful current of nutrient-rich seawater across thousands of protected baby shellfish It is a shellfish hotel, offering the animals complete protection from most predators while also offering them plenty to eat It is almost like forced feeding ' said Mr Blake The greater the current going over the shellfish, the more food and the more they eat

The shellfish hotel is an efficient system for raising shellfish quickly It takes a wild oyster three years to reach the three-inch harvestable size Using both the nursery and the hatchery, Mr Blake said he thinks he can raise a full size adult oyster in only two years

On the floating nursery raft are a quarter million baby shellfish, both oysters and quahaugs He has 140,000 oysters ranging in size from a dime to a quarter He also has 100,000 quahaugs each about an eighth of an inch in size, living and feeding together in racks Mr Blake is already selling his quahaugs to mainland communities in need of shellfish seed While he is still a year from making money with his cultured oysters, he can already realize some profit by selling his undersized quahaugs as field plantable seed



Mark Lovewell

JACK BLAKE WITH HIS FUTURE HARVEST

"We are farmers, not fishermen, ' said Mr Blake The cycle from planting to harvesting takes a good deal longer than for the ground-based farmer, the investment of time and energy is considerable and the technology supporting it is not yet proven

Mr Blake's oysters begin their lives in the floating hatchery, named Mollusk Madness It measures 14 feet in length and eight feet in width and its deck is just above the water's surface On board are electrical water and air pumps complicated filter systems and hoses

Close to the bow is a 250-gallon plastic tank with more than 3 million baby oysters suspended in the water Mr Blake feeds the oysters a special algae that is grown at the shellfish group hatchery On Saturday, the animals were one week old and eating plenty They are microscopic in size, smaller than 1/100 of a millimeter "In one week they will be a quarter of a millimeter in size By the end of October they will be a quarter-inch in size," said Mr Blake

It is a complicated operation, for all these shellfish are on life support Mr Blake filters the water where the microscopic oysters reside, which keeps predators away He also aerates the water using an electrical air pump A wind-powered generator above the hatchery augments the battery power, this helps keep the system running 24 hours a day before batteries are changed

In no time at all Mr Blake's oysters are expected to outgrow their space, but Mr Blake has plans to help them all the way to market size Mr Blake has to move his creatures all the time, culling their numbers down to manageable size But the critical time is now, when oysters are so tiny and most vulnerable

In two years, many of those oysters will go to market

Mr Blake's efforts could actually be helping the natural set of shellfish that already reside in the pond, for he is constantly releasing the shellfish he no longer has room to protect and feed

Shellfish farming is a complicated business Most of the science has been going on for years at the Martha's Vineyard Shellfish Group's hatchery on the Lagoon Pond Translating it to commercial growers has been the work of Rick Karney, director of the shellfish group From 1995 to 1998, the shellfish group has received $486,638 in federal funds to teach aquaculture to Island commercial fishermen, the funding came as the federal government tried to find ways to offer fishermen another livelihood following the collapse of fish stocks on Georges Bank

In this year, Mr Karney has administered an $89,255 grant to help fund Mr Blake and four other commercial shellfishermen who want to build and operate systems identical or like Mr Blake's Of that money, the National Fish and Wildlife Foundation gave the shellfish group a $65,000 grant, The Massachusetts Department of Food and Agriculture offered $5,255, and the floating hatchery alone received $19,000 from the Massachusetts Department of Food and Agriculture The participating Edgartown shellfishermen are Roy Scheffer, Ray Gailey Scott Castro, Tom Berry and Mr Blake

On Saturday afternoon, a high-speed boat pulled up alongside Mr Blake's floating hatchery "What are you doing?" asked John McBride of Edgartown and Boston

"I'm growing shellfish," replied Mr Blake 'I get this question all the time '

"Good luck, ' said Mr McBride before he threw the throttle on his power boat and sped off